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(54) Multiscan display mode for a plasma display panel

(57) In the field of video displaying the low video levels do not generate large area flicker. For displaying video sources with higher frame rate, it is therefore the idea of the invention, to extract from two corresponding pixels of two successive video frames a common portion (V_x) that will be displayed at a sub-frequency $f_v/2$ while the individual portions (V_1',V_2') of the corresponding pixels video are displayed at the correct high frequency f_v. The time period for displaying two frames is divided into three sub-groups. Two groups of sub-fields with similar sizes, for displaying the individual portions (V_1',V_2') and one group of sub-fields, called extra-codes, for displaying the common portion (V_x). This enables to eliminate large area flicker artifacts from PDPs, when displaying 50Hz based video norms by using upconverted 100Hz video sequences and to display real high frequency video on the PDP (ca. up to 120Hz) without frame dropping.

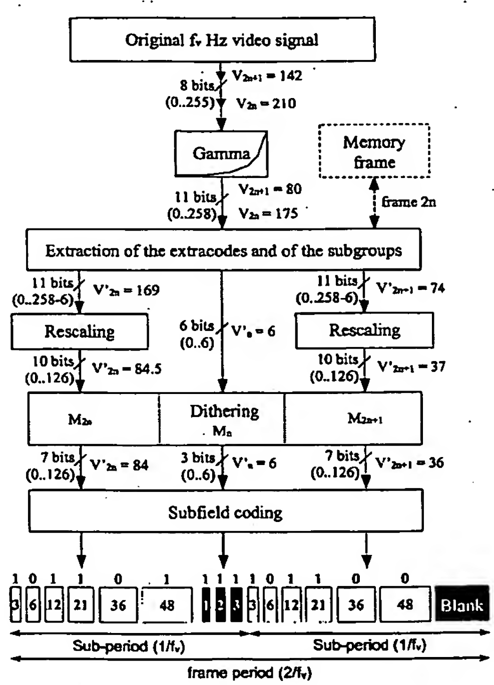

Fig. 6

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Description

[0001] The present invention relates to a method for displaying video pictures, the video pictures consisting of pixels, the pixels being digitally coded in code words determining the lengths of the time period during which the corresponding pixel of the display is activated in one frame, wherein to each bit of a code word a certain activation duration is assigned, hereinafter called sub-field weight. Particularly, the present invention relates to a multiscan display mode in which low video levels (dark pixels) are displayed with a lower frame repetition rate than the high video levels (bright pixels).

Background

[0002] A Plasma Display Panel (PDP) utilizes a matrix array of discharge cells, which could only be "ON", or "OFF". Also unlike a CRT or LCD in which gray levels are expressed by analog control of the light emission, a PDP controls the gray level by modulating the number of light pulses per frame. This time-modulation will be integrated by the eye over a period corresponding to the eye time response.

[0003] For stationary pictures, this time-modulation repeats itself, with a base frequency equal to the frame frequency of the displayed video norm. As known from CRTs, a light emission with base frequency of 50Hz, introduces large area flicker, which can be eliminated by field repetition with the 100Hz Upconversion technology for CRT TV receivers.

[0004] On the one hand this large area flicker artifact is reduced on a PDP since the duty cycle of light emission is longer. On the other hand since PDPs offer a larger size and so a larger viewing angle, even a reduced large area flicker becomes objectionable in terms of picture quality.

[0005] The solution, which is implemented in the European 100Hz Upconversion TV technology, is to display twice as many frames/fields (by repeating each frame/field or by interpolating extra-frames/fields) in the same time period (20ms), which corresponds to displaying a 100Hz video. For clarification the term "frame" in TV technology means a complete video picture. The standard TV systems NZSC, PAL, SECAM use the interlace scanning so that a frame consists of two "fields" wherein the first field all odd video lines are displayed and in the second field all the even video lines are displayed. In the 50Hz TV systems like PAL and SECAM a complete video picture is transmitted in a 40 ms time raster corresponding to a 25Hz frame repetition rate. The fields are transmitted in 20ms time raster corresponding to 50Hz field repetition rate. The 100Hz Upconversion technology mostly tackles the problem of large area flickering, but only by a pseudo frame/field repetition. So it does not permit to display real high frame rate video on the TV screen. This solution, as it is, is not really conceivable on the PDP since to display twice as many frames per second, twice as many sub-fields would be required (for the same quality).

[0006] Plasma displays are operated in progressive scanning mode in order to avoid a strong line flickering artefact. From another European Patent Application of the applicant (EP-A-0 982 708) a solution is known how to create a pseudo-100Hz component on the PDP, but this cannot be used to display the video frames coming from a video source reproducing video frames with a rate equal or higher than 75Hz.

[0007] The same limitation occurs when handling high frequency video signals coming from PC applications. In this case PDPs usually drop some frames and display a video at 60 Hz, losing the advantages of the original high frequency video, and introducing some problem with motion artifacts since some frames are constantly dropped.

Invention

[0008] It is the object of the present invention to provide a technique, which permits to display on a matrix display high frequency video sequences (for PC application mainly, which today use a frame rate of 75Hz or higher), preserving the motion quality of the input sources.

[0009] According to the present invention this object is solved by the solution claimed in method claim 1. The inventive method is characterised by the steps of extracting a common portion of the video values for corresponding pixels in two or more successive video frames, displaying the common portion of the video values with a reduced frame repetition frequency and displaying the individual portions of the video values with the real frame repetition frequency of the video source.

[0010] In other words, this invention consists in a different sub-field organization, with a new principle of sub-field coding, which permits to display high vertical frequency (f_v Hz) video.

[0011] The basic idea of this invention is that low levels, i. e. short activation durations of the pixels (dark pixels), do not generate flicker or motion artefacts (like judder), so they can be displayed at a sub-frequency ($f_v/2$ Hz) while the rest of the video is displayed at the correct frequency (f_v Hz).

[0012] To do this, the frame period may be tiled in three sub-groups:

- Two groups of sub-fields with similar sizes, being included in a $1/f_v$ ms time frame (two sub-periods of the $f_v/2$ Hz frame rate) corresponding to a f_v Hz component.

- One group of sub-fields, called extra-frame or extra-codes, being included between the two previous sub-groups and corresponding to a $f_v/2$ Hz component for the low levels.

[0013] Further advantageous embodiments are apparent from the dependent claims.

Drawings

[0014] The present invention will now be described in more detail along with the attached drawings showing in:

Fig. 1 the human eye temporal response characteristic;

Fig. 2 shows the cell structure of the plasma display panel in the matrix technology;

Fig. 3 shows the conventional ADS addressing scheme during a frame period;

Fig. 4 an example of a sub-field organisation for sub-field coding according to one embodiment of the present invention;

Fig. 5 a principle drawing for illustrating the multiscan concept;

Fig. 6 a flow chart for implementing the multiscan concept according to the present invention; and

Fig. 7 a block diagram of a hardware implementation of the multiscan concept.

Detailed Description of the Invention

[0015] The following embodiments show best modes of applying the present invention.

[0016] As already discussed the large area flickering is a real problem in countries like in Europe using a 50Hz frame repetition rate for TV transmissions. However, even in the case of 60Hz TV systems like NTSC used in the United States and Japan, such a flickering will become disturbing in the future with the increase of the display size (since appearing on the periphery of the field of vision) as well as with the increase of the luminance values/contrast value.

[0017] Fig. 1 illustrates the human eye sensitivity to contrast values versus temporal frequency of the video source for different luminance values. As can be seen clearly, the contrast sensitivity of the human eye decreases rapidly with decreasing luminance.

[0018] For these reasons the present concept for displaying high frequency video is not only an advantage for countries with 50Hz TV technology but also for other countries (cf. the video output of a modern PC tends to 75Hz or higher instead of 60Hz video sequences).

[0019] The principle of the invention provides for possibilities of either doubling the frame repetition rate (when this one is lower than 60Hz for example) or display a video with an increased high frame rate (greater than 60Hz) by using a limited number of sub-fields but with an acceptable quality and all the advantages of a high frame rate video (less flicker, natural motion, etc.).

[0020] For this invention, the input video signal can be either a high frame rate video signal (for example 85Hz from a PC graphic card or 100Hz from an HDTV source TV), which can normally not be displayed by the PDP (because it requires too many sub-fields per unit of time) or a low frame rate video (for example 50Hz), which generates large area flicker. In the last case (50HZz), the frequency is doubled by repeating each frame, and so one obtains a high frequency video displaying.

[0021] The aim of the present invention is also to display this high frequency video signal, on a display where the light generation is done in small pulses, and the small pulses are grouped in sub-fields of different weights, like PDP, DMD, OLED, etc.

[0022] The principle structure of a plasma cell in the so-called matrix plasma technology is shown in Fig. 2. Reference number 10 denotes a face plate made of glass, with reference number 11 a transparent line electrode is denoted. The back plate of the panel is referenced with reference number 12. There are 2 dielectric layers 13 for isolating face and back plate against each other. In the back plate column electrodes 14 are integrated being perpendicular to the line electrodes 11. The inner part of the cells consists of a luminance substance 15 (phosphorous) and separator 16 for separating the different coloured phosphorous substances (green 15a) (blue 15b) (red 15c). The UV radiation caused by the discharge is denoted with reference number 17. The light emitted from the green phosphorous 15a is indicated with an arrow having the reference number 18. From this structure of a PDP cell it is clear that there are three plasma cells necessary, corresponding to the three colour components RGB to produce the colour of a picture element (pixel)

of the displayed picture.

[0023] The grey level of each R, G, B component of a pixel is controlled in a PDP by modulating the number of light pulses per frame period. The eye will integrate this time modulation over a period corresponding to the human eye response. The most efficient addressing scheme should be to address n times if the number of video levels to be created is equal to n. In case of the commonly used 8 bit representation of the video levels, a plasma cell should be addressed 256 times according to this. But this is not technically possible, since each addressing operation requires a lot of time (around 2 μs per line > 960 μs for one addressing period > 245 ms for all 256 addressing operations), which is more than the 20 ms available time period for 50 Hz video frames.

[0024] From the literature a different addressing scheme is known, which is more practical. According to this addressing scheme a minimum of 8 sub-fields (in case of an 8 bit video level data word) are used in a sub-field organization for a frame period. With a combination of these 8 sub-fields it is possible to generate the 256 different video levels. This addressing scheme is illustrated in Fig. 3. In this figure each video level for each colour component will be represented by a combination of 8 bits with the following weights:

1/2/4/8/16/32/64/128

[0025] To realize such a coding with the PDP technology, the frame period will be divided in 8 lighting periods called sub-fields, each one corresponding to a bit in a corresponding sub-field code word. The number of light pulses for the bit "2" is double as for the bit "1" and so forth. With these 8 sub-periods it is possible, through sub-field combination, to build the 256 grey levels. The standard principle to generate this grey level rendition is based on the ADS (Address Display Separated) principle, where all operations are performed at different times on the whole display panel. At the bottom of Fig. 3 it is shown that in this addressing scheme each sub-field consists of three parts, namely an addressing period, a sustaining period and an erasing period.

[0026] In the ADS addressing scheme all the basic cycles follow one after the other. At first, all cells of the panel will be written (addressed) in one period, afterwards all cells will be lighted (sustained) and at the end all cells will be erased together.

[0027] The sub-field organization shown in Fig. 3 is only a simple example and there are very different sub-field organizations known from the literature with e.g. more sub-fields and different sub-field weights. Often more sub-fields are used to reduce moving artefacts and "priming" could be used on more sub-fields to increase the response fidelity. Priming is a separate optional period, where the cells are charged and erased. This charge can lead to a small discharge, i.e. can create background light, which is in principle unwanted. After the priming period an erase period follows for immediately quenching the charge. This is required for the following sub-field periods, where the cells need to be addressed again. So priming is a period, which facilitates the following addressing period, i.e. it improves efficiency of the writing stage by regularly exciting all cells simultaneously. The addressing period length can be equal for all sub-fields, also the erasing period length. However, it is also possible that the addressing period length is different for a first group of sub-fields and a second group of sub-fields in a sub-field organization. In the addressing period, the cells are addressed line-wise from line 1 to line n of the display. In the erasing period all the cells will be discharged in parallel in one shot, which does not take as much time as for addressing. The example in Fig. 3 shows the standard sub-field organisation with 8 sub-fields inclusive the priming operation. At one point in time there is one of these operations active for the whole panel.

[0028] The problem with high frequency video, is that as the frame period is reduced, less time is available for making small light pulses thereby reducing the achievable contrast values or if the number of light pulses shall be preserved, the number of sub-fields need to be reduced thereby reducing the grey scale portrayal.

[0029] It is the idea of the present invention that as the human eye is more sensitive to flicker in the higher levels of luminance, the low levels can be displayed with a lower frequency (and so they require less sub-fields per unit of time) since they do not introduce judder or other motion artifacts. The low frequency component is extracted from two consecutive frames (which are identical if the frequency has been doubled). Owing to this, less sub-fields are required, and so the picture quality can be preserved.

[0030] In the following as an example the case of a real 100Hz (f_v) video signal to be displayed on the PDP will be used, in order to simplify the exposition. But as said previously the same principle can be used with a frequency between 60 and 120Hz.

[0031] So in order to display this 100Hz (f_v) video signal:

- First, the maximum low level, *m*, which will be displayed at 50Hz ($f_v/2$), has to be chosen. Then from two consecutive frames for each pixel a low level (inferior or equal to m) has to be found; it can be the average of both video levels of the two frames, or simply a selection of one of the two low levels, e.g. the minimum of the maximum of both video levels. This selected low level will be coded with sub-fields named extra-codes in an extra-frame.

- Then the maximum low level, *m*, is subtracted from the high video levels of the two frames. The new high video levels will be coded independently with a same code (sub-field weight gradation), but the code words control

different sub-fields in the frame period.

[0032] In the following, the computation of the extra-frame and the sub-frames will be demonstrated.

[0033] Considering that the extra-codes of the extra-frame for two consecutive frames are displayed with a frequency twice lower than the rest of the video, their weight has to be twice as big than the one of the sub-groups: a value V (= 1 Cd for the luminance) for the extra-codes of a 50Hz picture is equivalent to a level $V/2$ (= $1/2$ Cd for the luminance) for one 100Hz (f_v) component.

[0034] So for example if V_1 and V_2 are the values of the video levels of two consecutive 100Hz frames, and m the maximal video level that will be displayed at 50Hz ($f_v/2$), the value of the extra-code V_X and the new values V_1' and V_2' of the two video levels, which will be coded in the sub-groups (are) could be:

- V_x is the average of the low levels of the two frames.
  In this case:

$$V_X = (\mathrm{Min}(m,\ V_1) + \mathrm{Min}(m,\ V_2))/\ 2$$

$$V_1' = V_1 - \mathrm{Min}(m,\ V_1) = \mathrm{Max}(0,\ V_1 - m)$$

$$V_2' = V_2 - \mathrm{Min}(m,\ V_2) = \mathrm{Max}(0,\ V_2 - m)$$

- V_x is the low level of the second frame. In this case:

$$V_X = \mathrm{Min}(m,\ V_2)$$

$$V_1' = V_1 - \mathrm{Min}(m,\ V_1) = \mathrm{Max}(0,\ V_1 - m)$$

$$V_2' = V_2 - \mathrm{Min}(m,\ V_2) = \mathrm{Max}(0,\ V_2 - m)$$

- Alternatively the low level of the first frame could be used. In this case:

$$V_X = \mathrm{Min}(m,\ V_1)$$

$$V_1' = V_1 - \mathrm{Min}(m,\ V_1) = \mathrm{Max}(0,\ V_1 - m)$$

$$V_2' = V_2 - \mathrm{Min}(m,\ V_2) = \mathrm{Max}(0,\ V_2 - m)$$

- Further alternatively in each case the smaller one of the two low levels could be used. In this case a comparison of the two low levels needs to be performed.

[0035] The low level, V_X is coded with the sub-fields of the extra-frame, and the sub-frames, V_1' and V_2', with the sub-fields of the subgroups.

[0036] The extra-frame is inserted between the two sub-frames, as it can be seen on Fig. 4.

[0037] A plasma display has a linear response characteristic. The CRT displays have the well known gamma function response characteristic. That's why the input video signal is gamma corrected before being transmitted to a CRT display. This gamma correction needs to be removed from the input video signal if the signal is input to a PDP. A gamma transformation is used for this purpose. The gamma transformation reinforces the input video signal nonlinearly.

[0038] Like usual, in order to improve the picture quality, dithering can be used. Dithering is a well-known technique used to reduce the effects of quantisation noise due to a reduced number of displayed levels by adding artificial levels in-between two levels. The dithering technique is disclosed in greater detail in another application of the applicant, see

WO 01/71702. For the disclosure of the present invention it is expressively referred to the WO document.

[0039] For the sub-field organisation according to the invention the picture quality can be enhanced by optimisation of dithering. The added dithering pattern is different for the three groups: if a cell-based dithering on 4 frames (4 masks: M_1, M_2, M_3, M_4) is used, then the patterns will be used as follows:

Frame 1 (50Hz)			Frame 2 (50Hz)		
Frame 1	XCode	Frame 2	Frame 3	XCode	Frame 4
M_1	M_1	M_2	M_3	M_2	M_4

Frame 3 (50Hz)			Frame 4 (50Hz)		
Frame 5	XCode	Frame 6	Frame 7	XCode	Frame 8
M_1	M_3	M_2	M_3	M_4	M_4

[0040] It is interesting to notice here that owing to this, the dithering is less perceptible as its frequency is higher than it would be without this invention (except for the extra-codes).

[0041] With the sub-field organisation shown in Fig. 4 used for encoding, 15 sub-fields are used to encode two 100Hz frames, but the picture quality is good in the low levels as well as in the other parts of the gray scale.

[0042] Fig. 5 illustrates the advantages of the present invention in comparison to the prior art solution according to EP-A-0 982 708 in the case of a white circle moving on a black background:

[0043] In the multiscan concept illustration the different slices represent the sub-fields for the sub-groups, and the slices above a black background layer the sub-fields for the extra group. Whereas in the prior art the pseudo frame repetition creates double edges, the multiscan concept respects the motion. In the example shown in the drawing, the extra-codes are extracted from the second sub-frame and as it can be seen, in this example this does not degrade the motion.)

[0044] To implement the invention in a PDP a flow chart of the sub-field coding process is presented in Fig. 6. In the example of Fig. 6 the maximum low level displayed in 50Hz raster is m=6. The frame memory in Fig. 6 is optional since it is only necessary when the extra-codes are computed from the two 100Hz frames.

[0045] An input video level V_{2n} is equal to 210, and an input video level of the corresponding pixel of the following 100Hz frame is equal to 142. After the gamma transformation with rescaling to the maximum value 258, the 11 bit output data, one obtains is $258*(210/255)^2=175$ and $258*(142/255)^2=80$. The maximum value 258 is the sum over all sub-field weights in the sub-field organisation. The value 258 is selected for rescaling because it allows to directly subtract the maximum low level m=6 from the input values. This is performed in the extraction step after the gamma transformation. Since the maximal value for the extra-codes is equal to 6 and the two video values are superior to 6, the extra-codes will be equal to 6. So one has to subtract the value 6 from both input values leading to 175-6=169 and 80-6=74. In the example of Fig. 6 these video values have to be rescaled to the value 126 (the sum of the sub-field weights of the sub-frames), giving 126*(169/252)=84.5 and 126* (74/252) =37.

[0046] The code (3/6/12/21/36/48) for the sub-groups permits to encode all video-level multiples of 3, the other levels are obtained by dithering. So finally a level of 84 is encoded.

[0047] If one of the input video values is less than the maximum low level 6, then the extracted extra-code will be equal to the low input video level. In the following rescaling step the video value of the extra-code will be subtracted only from the high input video value. The low input video value remains unchanged and will be displayed solely with the sub-fields of the extra frame.

[0048] In case that both input video values are ≤6, the extra-code will also be extracted by determining the lowest value. The higher value will be subject of rescaling and dithering as explained before.

[0049] Fig. 7 describes a possible circuit implementation of the invention. RGB input video data is forwarded to the gamma function transformation unit 20: this can be a LUT or a software program for performing the mathematical function. The outputs of this block are forwarded to the multiscan coding block 21 that extracts the extra-codes, performs the rescaling and outputs the new values of the sub-frames. The operation of the multiscan coding block 21 can be activated or deactivated with the MSC control signal generated by the plasma control block 26. E.g. if the input video signal is from a standard 60Hz video source, the multiscan block 21 will be deactivated and if the input video signal is from a 100Hz video source (e.g. PC) the multiscan block 21 is activated.

[0050] This multiscan coding block 21 can use an optional frame memory 22 when the extra-codes are extracted from the two sub-frames; but this can be avoided by extracting the extra-codes from one single sub-frame.

[0051] To the rescaled video values output of the multiscan block 21, the dithering values will be added in the dithering

unit 23 and this can be configured via the DITH signal from the plasma control block 26.

[0052] The same block will configure the sub-field encoding block 24 to take into account or not that the multiscan mode is activated or not. The sub-field code words from the sub-field coding block 24 are further processed in the well known manner including serial parallel conversion in block 25 for line-wise driving of the PDP.

[0053] The present invention is applicable to all displays based on the principle of duty-cycle modulation (pulse width modulation) of light emission. In particular it is applicable to DMDs (digital micro mirror devices). It eliminates large area flicker artifacts from PDPs, when displaying 50Hz based video norms and permits to display high frequencies on the PDP (e.g. 120Hz) without frame dropping, particularly in the field of multimedia applications.

[0054] A number of modifications are possible that are considered to also fall under the scope of the invention. For example the algorithm to determine the extra codes as being disclosed is based on a pair-wise evaluation of pixels from two consecutive frames. This algorithm could be modified in a manner that more than two corresponding pixels are involved in the evaluation process for the two consecutive frames.

Claims

1. Method for displaying video frames, wherein each video frame is displayed by activating pixels forming a display, and a sequence of frames is displayed with a main frame repetition frequency, **characterized by** the steps of extracting a common portion (V_x) of the video values for corresponding pixels in two or more successive video frames, displaying the common portion (V_x) of the video values with a reduced frame repetition frequency and displaying the individual portions (V_1',V_2') of the video values with the main frame repetition frequency.

2. Method according to claim 1, wherein a threshold is provided that represents the maximum value for the common portion of the video values.

3. Method according to claim 2, wherein in case that one of the video values of corresponding pixels is below the maximum value for the common portion, this low value defines the common portion (V_x).

4. Method according to one of the claims 1 to 3, wherein the video values for the pixels are digitally coded in code words determining the length of the time period during which the corresponding pixel of the display is activated in one frame, wherein to each bit of a code word a certain activation duration is assigned, hereinafter called sub-field weight, wherein for the activation of the pixels in at least two consecutive frames a sub-field organisation is used in which there are arranged at least two groups of sub-fields for the individual portions (V_1',V_2') of the video values of the corresponding pixels and at least one group of sub-fields for the common portion (V_x) of the video values of the corresponding pixels in a time period equal to the length of at least two frame periods corresponding to the main frame repetition frequency.

5. Method according to claim 4, wherein the group of sub-fields for the common portion (V_x) is positioned in the middle of the time period equal to the length of at least two frame periods corresponding to the main frame repetition frequency and the two groups of sub-fields for the individual portions (V_1',V_2') are positioned in front and behind the sub-field group for the common portion (V_x).

6. Method according to one of the claims 1 to 5, wherein the individual portions (V_1',V_2') of the video values are rescaled before sub-field encoding to a value corresponding to the sum of the sub-field weights in the group of sub-fields for the individual portions of the video values.

7. Method according to one of the claims 1 to 6, wherein the main frequency lies in the interval of 60 and 120Hz.

8. Method according to one of claims 1 to 7, wherein said at least two frames are identical frames after upconversion to a higher frame rate.

9. Use of the method according to one of the previous claims in a plasma display apparatus.

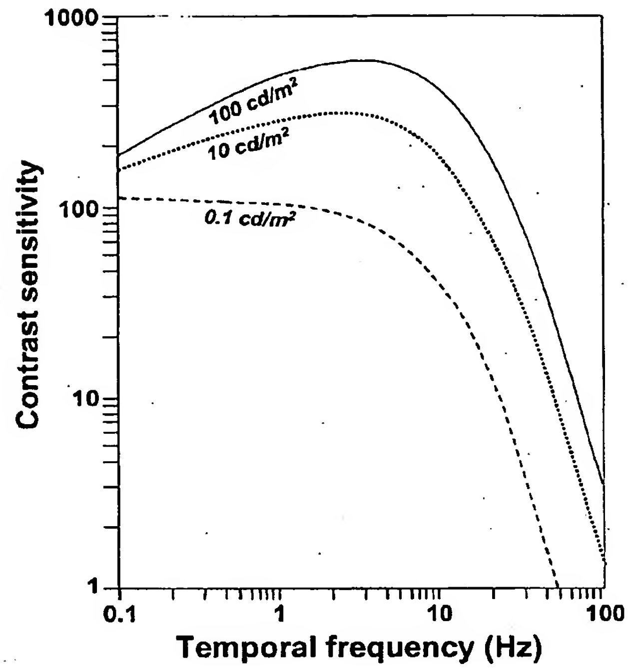

1000
100
10
1
Contrast sensitivity
100 cd/m²
10 cd/m²
0.1 cd/m²
0.1
1
10
100
Temporal frequency (Hz)

Fig. 1

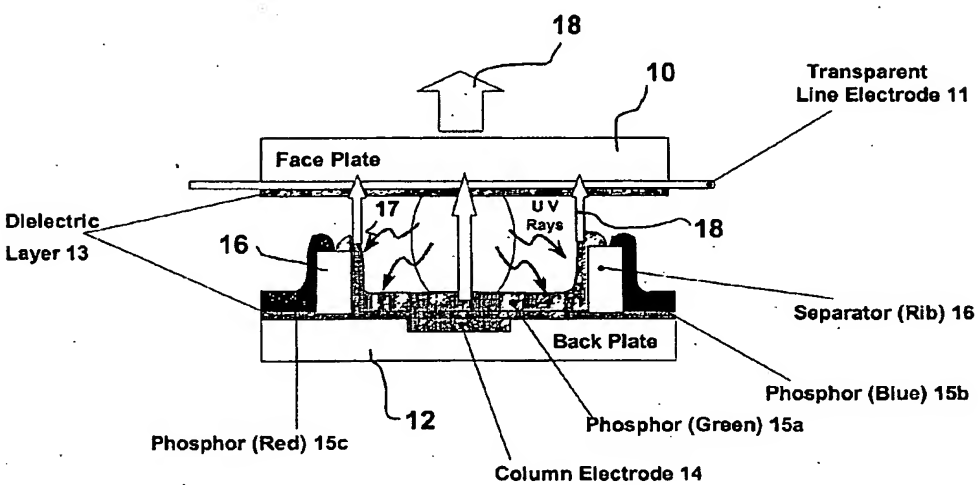

18
10
Transparent
Line Electrode 11
Face Plate
Dielectric
Layer 13
16
17
U V
Rays
18
Separator (Rib) 16
Back Plate
Phosphor (Blue) 15b
12
Phosphor (Green) 15a
Phosphor (Red) 15c
Column Electrode 14

Fig. 2

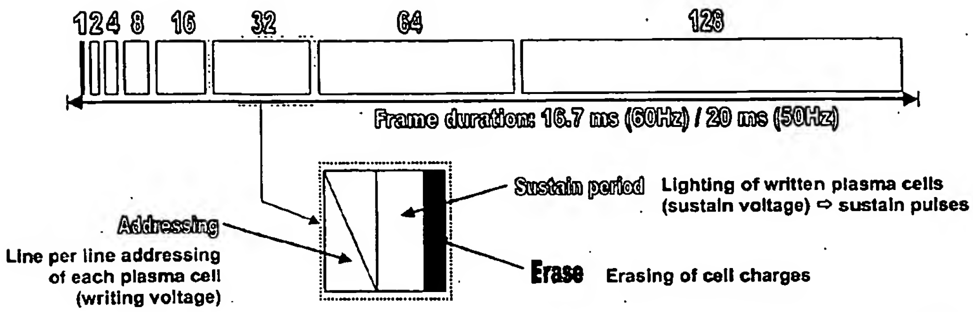


Fig. 3

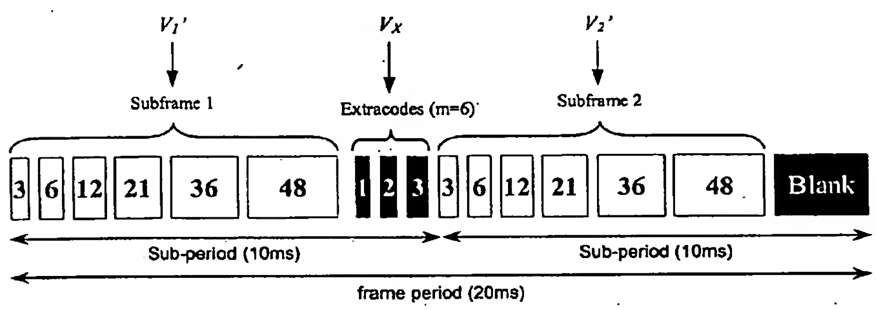


Fig. 4

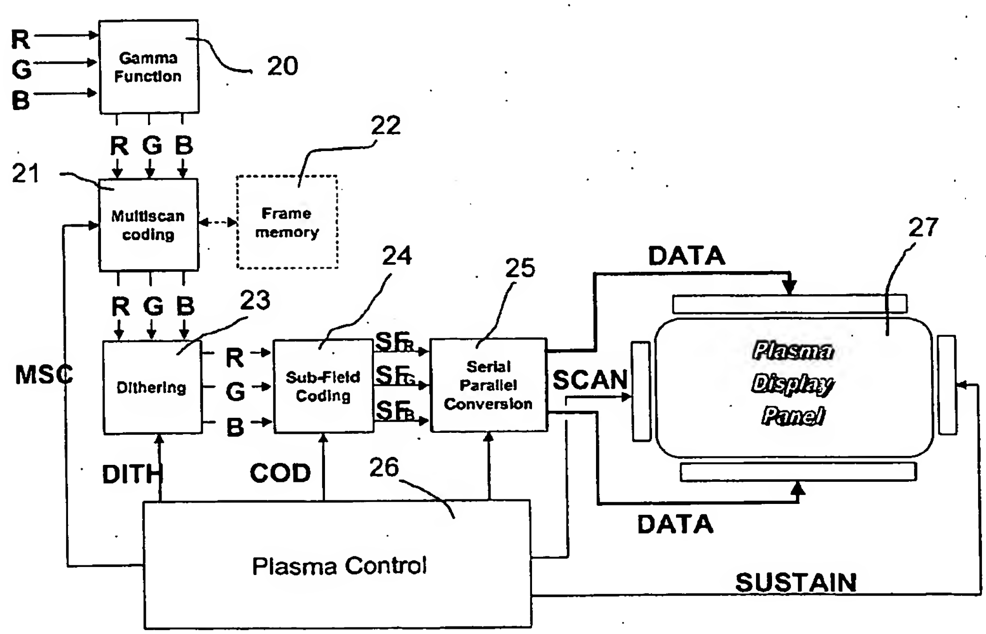
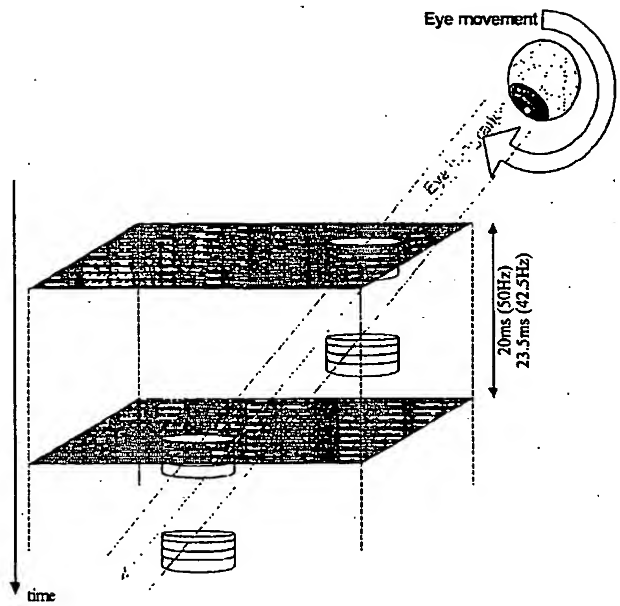
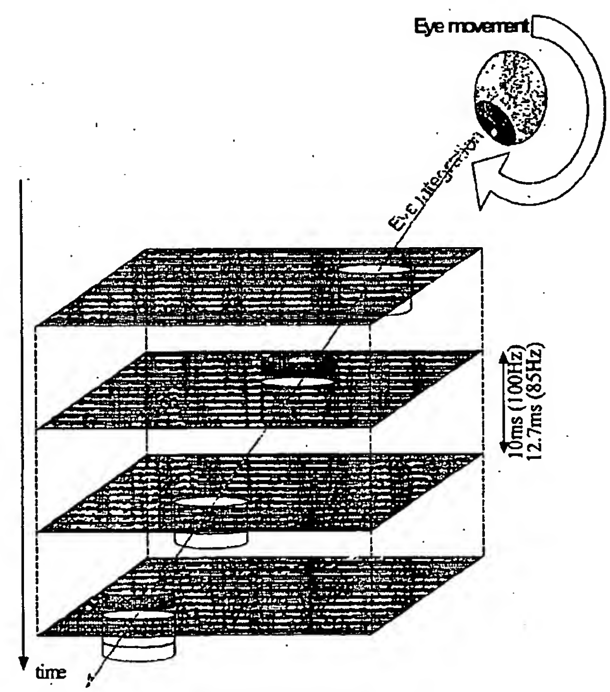


Fig. 7



Prior art



Multiscan concept

Fig. 5

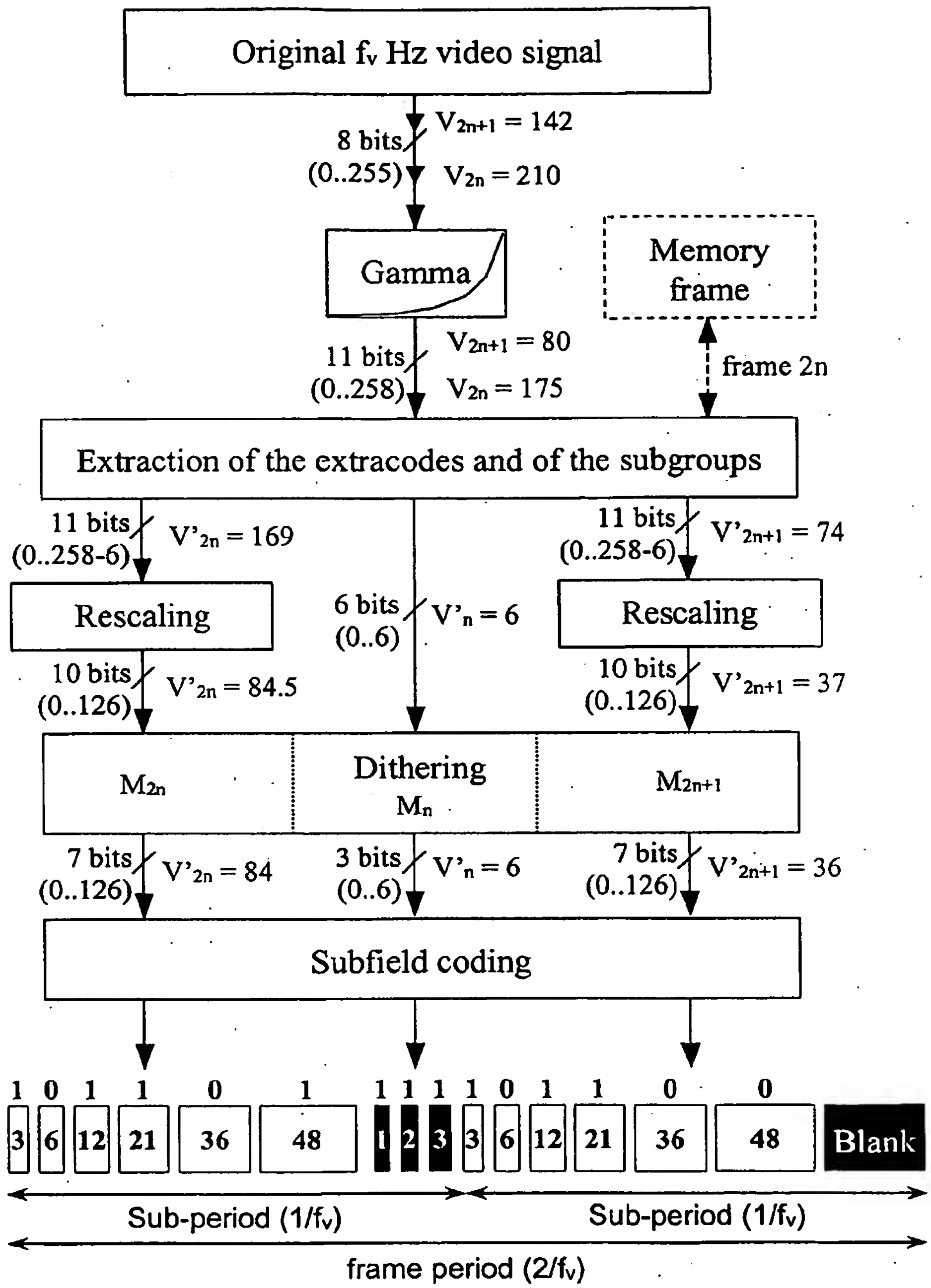

Original fv Hz video signal
8 bits (0..255)
V2n+1 = 142
V2n = 210
Gamma
Memory frame
11 bits (0..258)
V2n+1 = 80
V2n = 175
frame 2n
Extraction of the extracodes and of the subgroups
11 bits (0..258-6)
V'2n = 169
11 bits (0..258-6)
V'2n+1 = 74
Rescaling
6 bits (0..6)
V'n = 6
Rescaling
10 bits (0..126)
V'2n = 84.5
10 bits (0..126)
V'2n+1 = 37
M2n
Dithering
Mn
M2n+1
7 bits (0..126)
V'2n = 84
3 bits (0..6)
V'n = 6
7 bits (0..126)
V'2n+1 = 36
Subfield coding
1 0 1 1 0 1 1 1 1 1 0 1 1 0 0
3 6 12 21 36 48 1 2 3 3 6 12 21 36 48 Blank
Sub-period (1/fv)
Sub-period (1/fv)
frame period (2/fv)

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 02 09 0164

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	3 September 2002	Brandenburg, J

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